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(71) Applicant (for all designated States except US): DEN NOR-SKE STATS OLJESELSKAP A.S. [NO/NO]; Postboks 300 Forus, N-4001 Stavanger (NO).

(72) Inventors; and

(75) Inventors/Applicants (for US only) : BREIVIK, Kåre [NO/NO]; Ugleliveien, N-4120 Tau (NO). MIØEN, Stig, Arve [NO/NO]; Åsevangveien 23, N-7048 Trondheim (NO). SMEDAL, Arne [NO/NO]; Torjusholmen, N-4818 Færvik (NO). SYVERTSEN, Kåre [NO/NO]; Ribberåsen 7, N-4800 Arendal (NO).

(74) Agent: TANDBERGS PATENTKONTOR A/S; Postboks 7085 H, N-0306 Oslo (NO).

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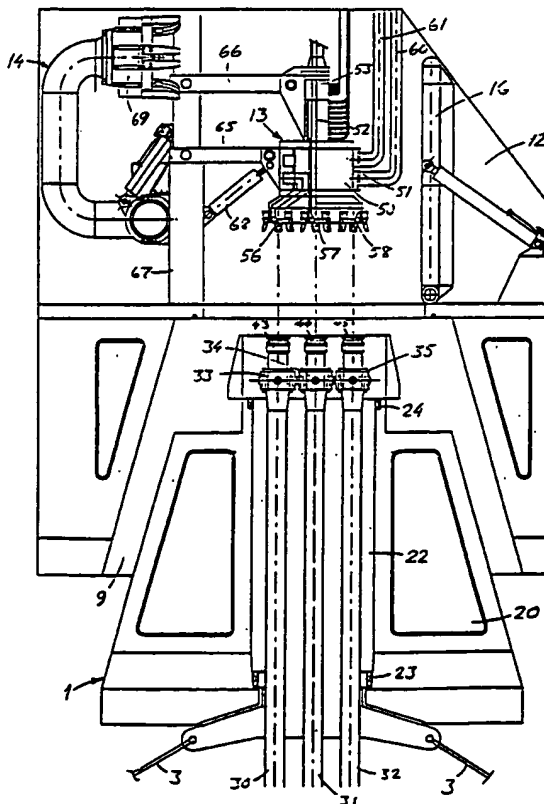
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(54) Title: A SYSTEM FOR USE IN OFFSHORE PETROLEUM PRODUCTION

## (57) Abstract

A system for use in offshore oil and gas production from production wells on the sea bed, comprising a submerged buoy (1) having an outer buoyancy member (20) which is arranged for introduction and releasable fastening in a submerged, downwardly open receiving space (9) in a vessel, and a central member (22) which is rotatably mounted in the outer member (20) and is anchored to the sea bed and is connected to at least one transfer line (30, 31, 32) extending from a respective production well up to the buoy (1), a shaft (10) extending between the receiving space (9) and the deck (11) of the vessel. The system comprises a swivel unit (13) which is installed at the lower end of the shaft (10) so that it is limitedly raisable and lowerable, and which is connected to a tube system on the vessel (8), the swivel unit (13) comprising inner and outer mutually rotatable swivel members and at its underside is provided with a number of coupling heads (56, 57, 58) for interconnection with corresponding connectors (43, 44, 45) arranged at the upper ends of the topical number of transfer lines (30, 31, 32), these lines at their upper end being suspended at the upper end of the central member (22) of the buoy (1).



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A system for use in offshore petroleum production

The invention relates to a system for use in offshore oil and gas production from production wells on the sea bed, comprising a submerged buoy having an outer buoyancy member which is arranged for introduction and releasable fastening in a submerged, downwardly open receiving space in a vessel, and a central member which is rotatably mounted in the outer member and is anchored to the sea bed and is connected to at least one transfer line extending from a respective production well up to the buoy, a shaft extending between the receiving space and the deck of the vessel.

A system of the above-mentioned type, for use in buoy loading and unloading, is disclosed in the international patent application No. PCT/NO92/00054. In such systems the submerged buoy forms a collecting point for one or more flexible risers and umbilical cables from e.g. a production system at the sea bed. The buoy is adapted to be raised and fastened in the receiving space of the topical vessel, to establish a transport system for the petroleum products from said system to holds in the vessel.

When a buoy of the introductorily stated type is secured in the receiving space in a vessel, the vessel is rigidly fastened to the outer buoyancy member of the buoy and is rotatable about the central member of the buoy which is anchored to the sea bed by means of a suitable mooring system. Thus, the buoy itself constitutes a turning body or turret about which the vessel is allowed to turn under the influence of wind, waves and water currents.

This buoy structure involves a number of essential advantages in relation to the previously known buoy loading systems. The central member of the buoy has a small diameter and a small mass, so that a correspondingly small diameter is obtained of the turning body, i.e. the outer buoyancy member of the buoy, and therewith a small rotary mass and a small rotational resistance. Connection and disconnection between vessel and buoy can be carried out in a simple and quick manner, even in bad weather with relatively high waves. Further, the buoy may remain connected to the vessel in all weathers, a quick disconnection being able to be carried out if a weather limitation should be

exceeded.

In a vessel which is adapted for use together with the mentioned buoy structure, the receiving space and the shaft arranged thereabove suitably are arranged in the bow portion of the vessel, as shown in the above-mentioned international patent application. This makes possible a relatively simple and cheap rebuilding of existing vessels for adaptation to such a buoy loading system, for use as shuttle tankers. The combination of a submerged receiving space and a shaft which extends between the receiving space and the deck of the vessel, in addition makes possible a system giving a high security in operation and a small risk for contaminating spills.

For a further description of the buoy structure mentioned above and of a vessel of the above-mentioned type, reference may also be made to the international patent applications Nos. PCT/NO92/00055 and PCT/NO92/00056.

As regards offshore oil and gas production by means of production vessels, there are known different solutions, i.a. of the type which is based on a submerged bottom-anchored buoy and a receiving space arranged in the vessel in the form of a moonpool which e.g. contains a turning cylinder or turret for reception and installation of the buoy. It is common to the known systems that they are relatively expensive, mainly because of large dimensions of the turning cylinder and the system on the whole. This results in that production vessels according to the prior art are not economically and practically usable in connection with minor or marginal oil fields. Thus, there is a need for simple mobile production solutions making possible an economic exploitation also of smaller oil fields, especially with little gas, and with a production rate of up to 5000 m<sup>3</sup> oil per day.

Thus, it is a main object of the invention to provide a system for use in offshore oil and gas production and which makes possible an efficient and economic utilization of e.g. smaller or marginal oil fields, the inherent advantages of the introductorily stated buoy loading system being utilized and retained.

The above-mentioned object is achieved with a system of the introductorily stated type which, according to the invention,

is characterized in that it comprises a swivel unit which is installed at the lower end of the shaft so that it is limitedly raisable and lowerable, and which is connected to a tube system on the vessel, the swivel unit comprising inner and outer mutually rotatable swivel members and at its underside is provided with a number of coupling heads for interconnection with corresponding connectors arranged at the upper ends of the topical number of transfer lines, these lines at their upper end being suspended at the upper end of the central member of the buoy.

A substantial advantage of the system according to the invention is that it gives reduced system dimensions because of the use of the special buoy which itself constitutes a turning body. This results in weight saving and a reduced equipment volume, something which gives substantially reduced costs.

The system according to the invention requires minimum rebuilding of shuttle tankers for the introductorily stated buoy loading system, for transition to production vessels. With such a production vessel, seasonal operations will be possible, in addition to continuous production from marginal fields, and also test production. The ship for example may be used for test production during the summer half in a period with a possible excess of shuttle tankers.

In connection with, or in addition to the above-mentioned fields of use, the system according to the invention will be suitable for use in connection with water injection, water purification plants, well stimulation, pumping of oil from ship wrecks located at the sea bed, etc. The system also is suitable for use in waters having floating ice and icebergs, the system when required making possible a quick disconnection, without any risk for damage of the submerged buoy.

The invention will be further described below in connection with exemplary embodiments with reference to the drawings, wherein

Fig. 1 shows a view of a vessel and a submerged buoy forming part of the system according to the invention;

Fig. 2 corresponds to Fig. 1, but shows the buoy raised and introduced in the receiving space of the vessel;

Fig. 3 shows a schematic sectional side view of a bow

portion of a vessel which is designed in accordance with the invention, and wherein a buoy is partly introduced in the receiving space of the vessel;

Fig. 4 shows the buoy and swivel arrangement in Fig. 3 on an enlarged scale;

Fig. 5 shows a segment of Fig. 4, on a further enlarged scale; and

Fig. 6 shows a schematic view of the coupling space in Fig. 4, at right angles to the sectional plane in Fig. 4.

Corresponding parts and elements are designated by the same reference numerals in the different drawing Figures.

In Fig. 1 there is shown a submerged buoy 1 which is anchored to the sea or ocean bed 2 by means of a suitable mooring system consisting of a number of anchor lines 3 and floating bodies 4, so that the buoy floats at a predetermined desired depth below the water surface 5, the buoyancy of the buoy then being in equilibrium with the weight of the mooring system. A flexible transfer line 6 extends between the buoy 1 and a production well 7 at the sea bed. Even if only one line 6 is shown, several lines may be arranged in practice in the form of one or more flexible risers (for production, injection, etc.) and an associated umbilical cable.

A vessel 8 in its bow portion is provided with a receiving space 9 and is brought into position with the receiving space located above the buoy 1. The vessel may be a shuttle tanker which is equipped as a production vessel and for this purpose will be provided with a modularized, deck-mounted processing plant and a burner means ("flare"). In preparation for production the buoy 1 is hoisted up and secured in the receiving space 9, as shown in Fig. 2.

Fig. 3 shows a schematic side view of the bow portion of a vessel 8 which is equipped to work as a production vessel in accordance with the invention. The vessel has a receiving space 9 and a shaft 10 which extends between the receiving space and the deck 11 of the vessel. At the lower end of the shaft, and more specifically in a coupling space 12, there is installed a swivel unit 13 which is provided with means for interconnection and cooperation with the buoy 1 when this is introduced and locked in place in the receiving space 9.

In the embodiment in Fig. 3 there has been taken as starting point a shuttle tanker of the implementation shown in the aforementioned international patent application No. PCT/NO92/00055. Thus, the space 12 is shown to contain a coupling unit 14 which is associated with a loading line (not shown) on the vessel, and which is intended for interconnection with a suitable buoy when the vessel is operated as a shuttle tanker. Further, the space 12 is connected to a drainage line 15 for emptying the shaft 10 of water, for example for inspection and maintenance purposes, either when a buoy is placed in a sealing manner in the receiving space 9 or when the space 12 is shut off from the sea by means of the shown shutter 16. A further drainage line (not shown) may be arranged for drainage of possible oil leakage or the like to a collecting tank on the vessel.

The shaft 10 further is connected to a conduit or line 17 leading to the inert gas and ventilation system of the vessel, so that the shaft when required may be filled with inert gas, as a safety precaution, a suitable closing means 18 being provided at the upper end of the shaft. In production, the space for coupling towards underwater buoy and multi-course swivel will be a critical and potentially gas and explosion hazardous region. This region preferably will be separated by a cofferdam, in addition to the fact that the space as mentioned may be filled with inert gas, or with water, to reduce the explosion hazard.

The buoy and swivel arrangement is further shown in Fig. 4.

The buoy 1 comprises an outer buoyancy member 20 which is arranged for releasable fastening in the receiving space 9 by locking means 21 (shown in Fig. 6), and a central member 22 which is rotatably mounted in the outer member 20 by means of the bearing means 23, 24, and which is anchored to the sea bed by means of the anchor lines 3. Apart from the riser arrangement in the central member 22 of the buoy, the fundamental construction and manner of operation of the buoy in all essentials corresponds to what is disclosed in the aforementioned international patent application No. PCT/NO92/00056, and reference is made to this application for a further description of the general buoy structure.

In the illustrated embodiment, three flexible transfer

lines 30, 31, 32 are introduced in the central member 22 of the buoy and suspended at the upper end thereof, as shown in Fig. 4. These lines e.g. may consist of a pair of flexible risers, one for production and one for injection, and an umbilical cable which i.a. may contain hydraulic and service lines. The upper end portions of the lines 30, 31, 32 are mounted in respective cardan joints 33, 34, 35. As shown in Fig. 5, the cardan joints consist of respective annular holding elements 36, 37, 38 which are suitably journaled in the upper portion of the central member 22 of the buoy about mutually perpendicular axes, more specifically - in the illustrated embodiment - a common axis which is designated 39, and axes 40, 41, 42 at right angles to the common axis. By means of this coupling arrangement and the inherent flexibility in the transfer lines 30, 31, 32, one achieves that the connectors 43, 44, 45 at the upper ends of the lines may adjust themselves to the position of corresponding coupling heads arranged at the underside of the swivel unit 13, so that a safe interconnection is achieved, as further described below.

The swivel unit 13 consists of a stack of swivels of a suitable type for the production case in question. In the illustrated embodiment the swivels consist of a pair of high pressure production swivels 50 and 51, a hydraulic swivel 52 and a service line swivel 53. Each swivel in the swivel assembly may be of a conventional construction and consists of inner and outer mutually rotatable swivel members. The arrangement appears more clearly in the enlarged view in Fig. 5 which shows the swivel assembly partly sectioned, otherwise in the same manner as Figs. 4 and 6. As regards the fluid-transferring swivels, an annulus, represented by 54 in Fig. 5, is defined between the inner and outer members of each swivel. The inner swivel member has a tube connection, represented by 55 in Fig. 5, communicating with the annulus and with a respective one of a number of coupling heads 56, 57, 58 arranged at the underside of the swivel unit 13, for interconnection with respective connectors at the upper ends of the transfer lines. The outer swivel member has a channel or a tube connection, represented by 59 in Fig. 5, communicating with the annulus and with an outer flange means for connection to connecting tubes arranged between the swivel unit and a tube system leading to the processing plant (not shown) of the vessel.



In Figs. 4-6 the swivels 50 and 51 are shown to be connected to such connecting tubes 60 and 61, respectively, which preferably are flexible to absorb vertical movement of the swivel unit 13 in connection with interconnection between the swivel unit and  
5 the transfer lines of the buoy, and to absorb occurring hull-induced movements between the swivel unit and the tube system of the vessel. Also the swivel units 52 and 53 are connected to connecting tubes 62 and connecting lines 63, respectively, which are also flexible, for the same purpose.

10 The arrangement and the course of the connecting tubes 60-63 across the coupling space 12 is not further shown, but the tubes will be able to extend upwards in the shaft 10 or be carried into the vessel hull from the coupling space, and forwards to the place for interconnection with said tube system  
15 on the vessel.

The coupling heads arranged at the underside of the swivel unit 13 are provided with gripping or locking dogs 64 (see Fig. 5) to provide for a safe mechanically locked connection with corresponding flanges on the connectors 43-45. This may be  
20 essential in connection with the high pressures which will be present in the production risers.

As best shown in Fig. 4, the swivel unit 13 is installed at the end of a pivot arm means consisting of a pair of arms 65, 66 which, at one end thereof, are articulated to the swivel  
25 unit and at their other ends are articulated to a vertical column 67. The arms 65, 66 are pivotable about the column (or alternatively the column is rotatable about its longitudinal axis), so that the swivel unit 13 can be pivoted to or away from a position above the central member 22 of the buoy. By means of the  
30 arms 65, 66 the swivel unit is also raisable and lowerable in a limited manner. Such a movement of the swivel unit is achieved by means of a hydraulic cylinder 68 which is shown to be connected between the column 67 and the swivel unit.

When the buoy 1 is to be pulled into the receiving  
35 space 9, the swivel unit will be pivoted away from the opening between the receiving space 9 and the coupling space 12. The buoy then can be pulled in in accordance with the procedure described in the international patent application No. PCT/NO92/00053. When the buoy has been pulled in and locked in place by the locking

means 21, the swivel unit is pivoted in place over the buoy. Thereafter the inner member of the swivel unit is turned by means of a suitable means (not shown) until the coupling heads 56-58 are located in a correct position above the connectors 43-45 of the transfer lines. This operation may be monitored by means of video cameras. Thereafter the swivel unit is lowered by means of the hydraulic cylinder 68, so that the coupling heads are connected in a sealing manner to the connectors, and so that the locking dogs 64 of the coupling heads form a locking engagement with the locking flanges of the connectors. The system then will be ready for production.

The coupling heads 56-58 as well as the connectors 43-45 may be provided with automatic shut off valves opening and closing automatically in connection with connection and disconnection, respectively, especially to limit oil spill in case of an emergency disconnection.

As mentioned above, the coupling unit 14 is intended for interconnection with a suitable loading/unloading buoy when the vessel is operated as a shuttle tanker. When the vessel is operated as a production ship, the coupling unit 14 will be pivoted to the "stowed" position shown in Fig. 4. In Fig. 6 the coupling unit is shown to be pivoted 90° to its operating position, and its coupling head 69 in practice then will be placed in a suitably centred position above the opening of the receiving space 9, even if the coupling unit in Fig. 6 is shown to be somewhat laterally displaced from this position.

P a t e n t   c l a i m s

1. A system for use in offshore oil and gas production  
5 from production wells on the sea bed, comprising a submerged buoy  
(1) having an outer buoyancy member (20) which is arranged for  
introduction and releasable fastening in a submerged, downwardly  
open receiving space (9) in a vessel, and a central member (22)  
which is rotatably mounted in the outer member (20) and is  
10 anchored to the sea bed and is connected to at least one transfer  
line (6; 30-32) extending from a respective production well (7)  
up to the buoy (1), a shaft (10) extending between the receiving  
space (9) and the deck (11) of the vessel (8), **CHARACTERIZED IN**  
that it comprises a swivel unit (13) which is installed at the  
15 lower end of the shaft (10) so that it is limitedly raisable and  
lowerable, and which is connected to a tube system on the vessel  
(8), the swivel unit (13) comprising inner and outer mutually  
rotatable swivel members and at its underside is provided with  
a number of coupling heads (56, 57, 58) for interconnection with  
20 corresponding connectors (43, 44, 45) arranged at the upper ends  
of the topical number of transfer lines (30, 31, 32), these lines  
at their upper end being suspended at the upper end of the  
central member (22) of the buoy (1).

2. A system according to claim 1, **CHARACTERIZED IN** that  
25 the swivel unit (13) is installed at the end of a pivot arm means  
(65, 66, 67) so as to be pivotable towards or away from a  
position above the central member (22) of the buoy (1).

3. A system according to claim 1 or 2, **CHARACTERIZED IN**  
that the swivel unit (13) and the tube system on the vessel (8)  
30 are interconnected by means of flexible tubes (60, 61).

4. A system according to any of the claims 1-3,  
**CHARACTERIZED IN** that the transfer lines (30, 31, 32) are  
suspended in the central member (22) of the buoy (1) by means of  
cardan joints (33, 34, 35).

35 5. A system according to any of the preceding claims,  
**CHARACTERIZED IN** that the swivel unit (13) is raisable and  
lowerable by means of a hydraulic cylinder (68).

6. A system according to any of the preceding claims,  
**CHARACTERIZED IN** that the swivel unit (13) consists of a swivel

stack containing a high pressure production swivel (50), a high pressure injection swivel (51), a hydraulic swivel (52) and a service line swivel (53).

7. A system according to any of the preceding claims,  
5 CHARACTERIZED IN that the shaft (10) at its lower end is connected to at least one drainage line (15) for drainage of liquid, such as water or leakage of transferred medium, such as oil.

8. A system according to any of the preceding claims,  
10 CHARACTERIZED IN that the shaft (10) is coupled to an inert gas and ventilation system (17) on the vessel (8).

1/5

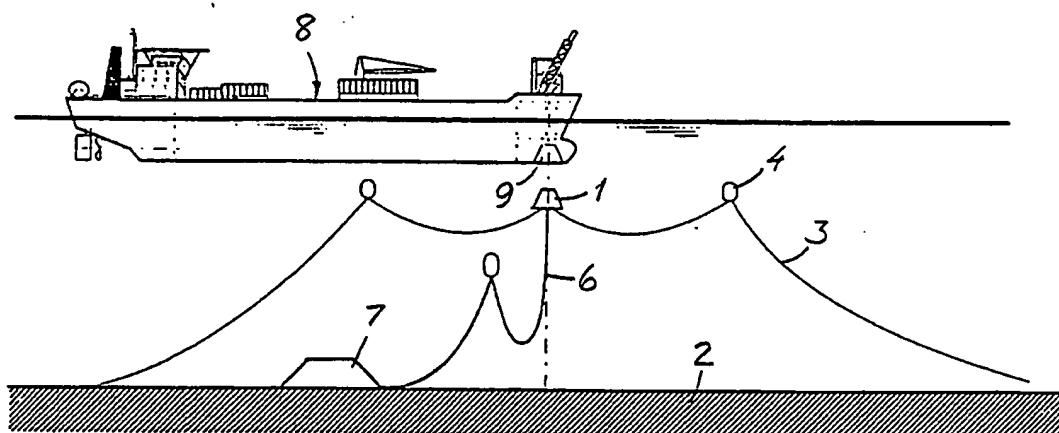


FIG. 1

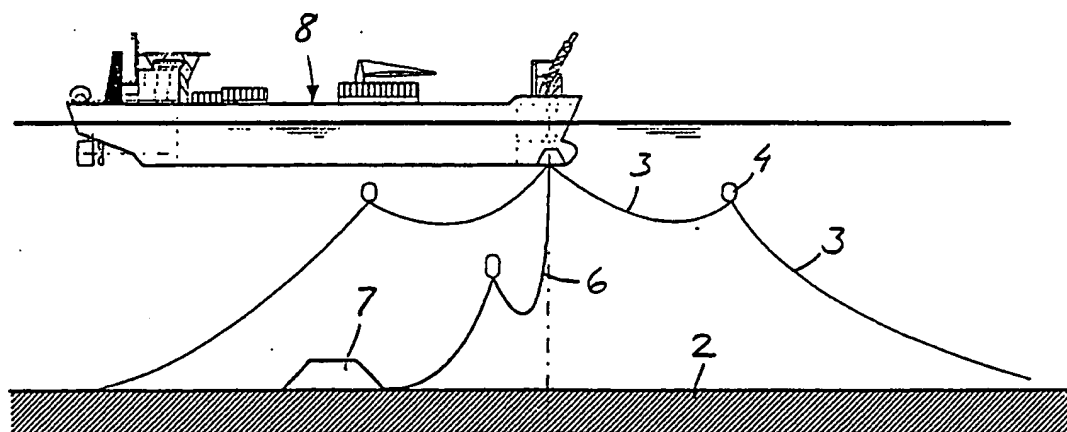


FIG. 2

2/5

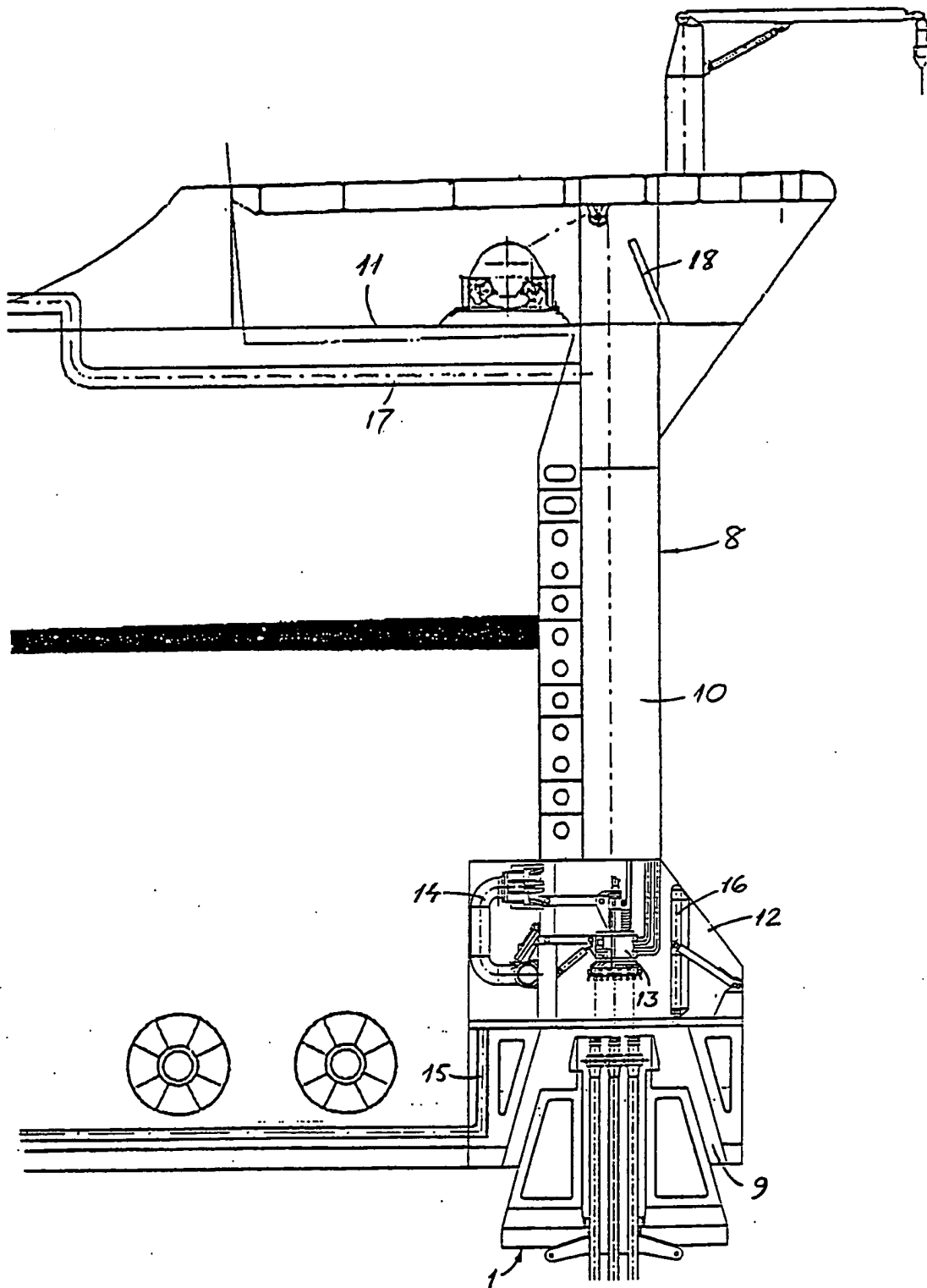


FIG. 3

3/5

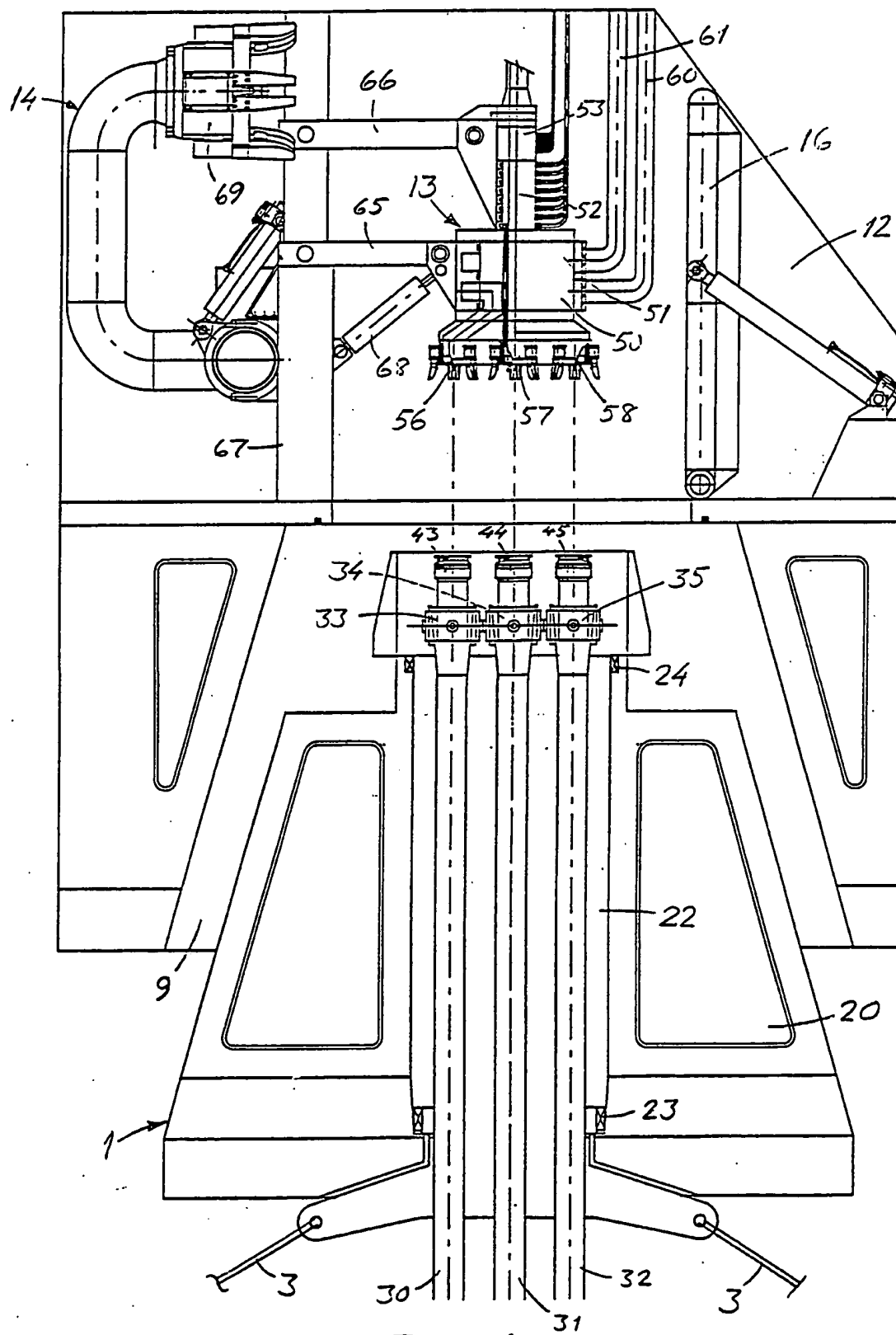


FIG. 4

4/5

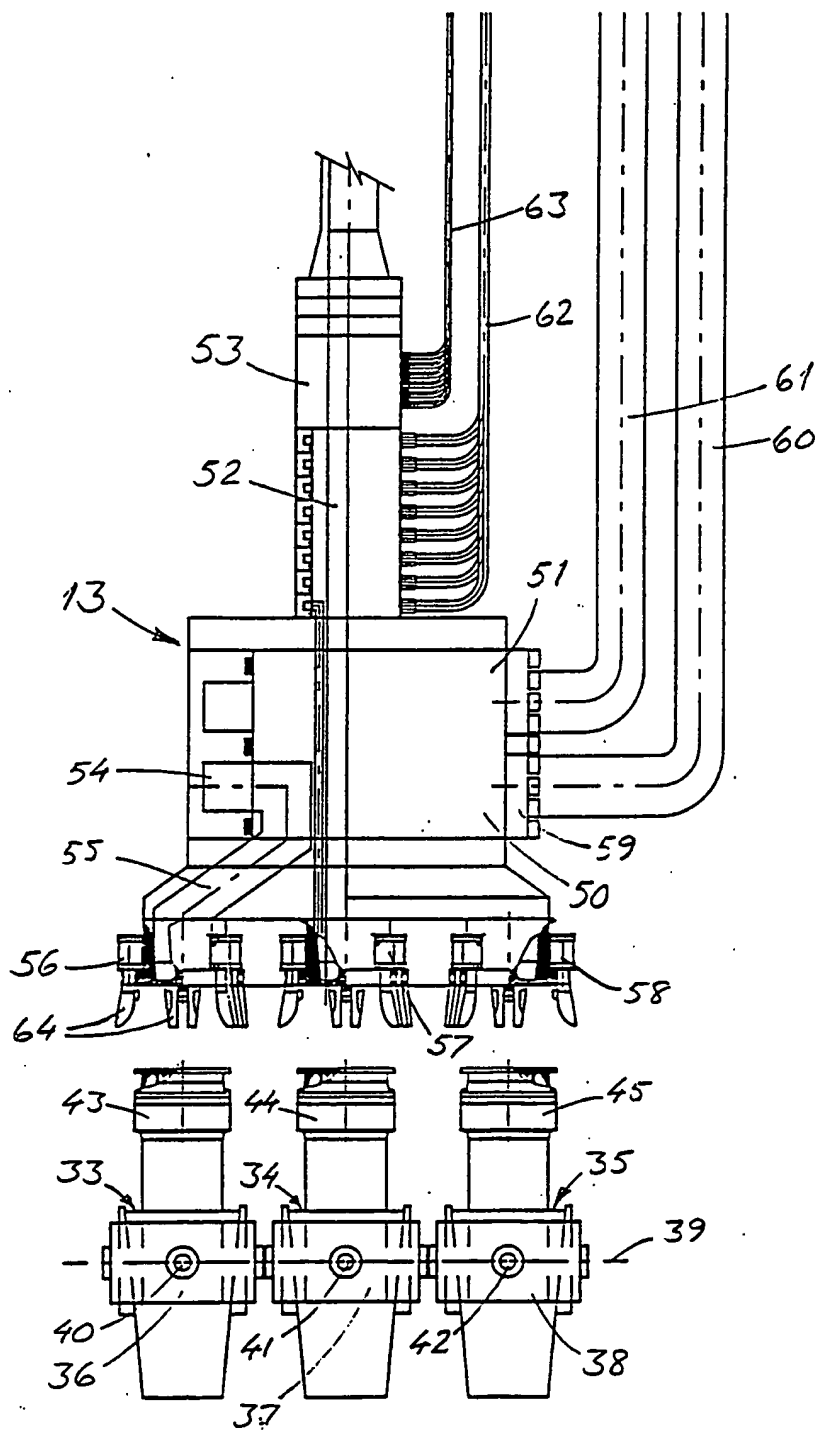


FIG. 5



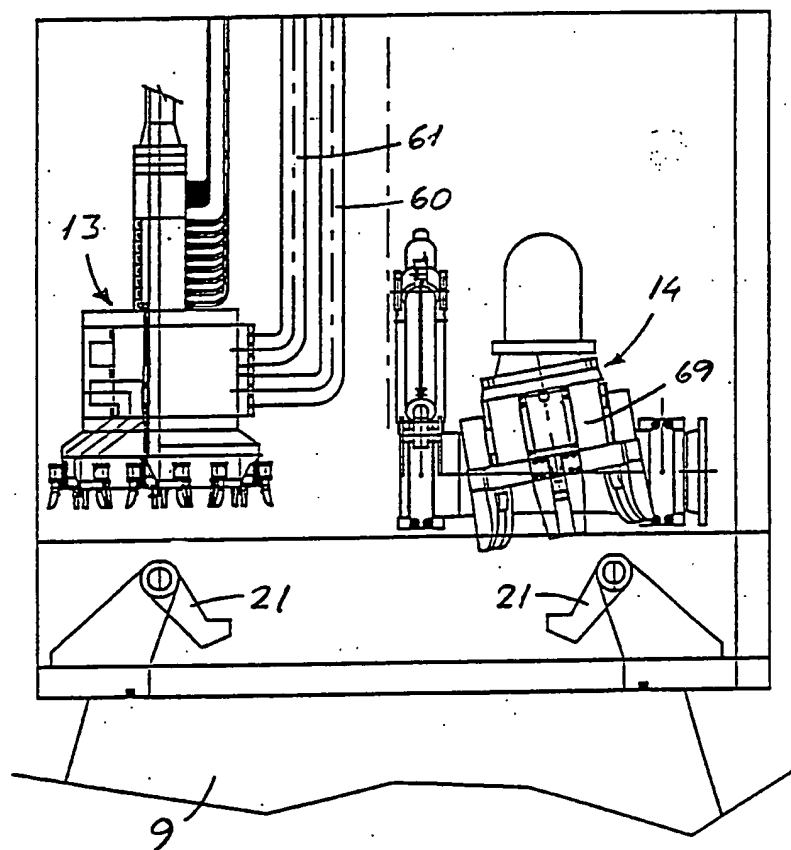


FIG. 6

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 93/00080

## A. CLASSIFICATION OF SUBJECT MATTER

IPC5: E21B 43/01, B63B 21/50

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: E21B, B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NO, B, 160294 (MOBIL OIL CORPORATION), 27 December 1988 (27.12.88)  --	1-8
A	NO, B, 164968 (BLOHM + VOSS AG), 27 August 1990 (27.08.90)  --	1-8
A	NO, B, 167906 (EXXON PRODUCTION RESEARCH COMPANY), 16 Sept 1991 (16.09.91)  -- -----	1-8

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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**INTERNATIONAL SEARCH REPORT**  
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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
NO-B-	160294	27/12/88	NONE	
NO-B-	164968	27/08/90	NONE	
NO-B-	167906	16/09/91	NONE	